Abstract Report of the Proceedings of the Committee appointed to superintend the Boring Operations in Fort William, from their commencement in December, 1835, *to their close in April,* 1840.

Several attempts have at different times been made to supply the deficiency of good water in Fort William, by boring through the strata on which it stands, in search of subterranean springs. The present operations, which form the most recent of the series, were originally commenced in December, 1835, but the site then selected was shortly afterwards abandoned in consequence of the operations having been impeded by a dislocation of the joints of the metallic tubes lining the bore. As all attempts made to rejoint the dislocated tubes proved unsuccessful, the Committee selected a new locality closely adjoining, however, to that of the original bore, no advantage being anticipated from any change of site within the limits of the Fort, the succession of strata, and the circumstances of their disposition, being alike within so small a space.

On the 2nd of April, 1836, the operations of the Committee were resumed, by commencing the excavation of a shaft, ten feet in diameter, ten feet in depth, interiorly rivetted with good masonry, and having its bottom strongly planked, with masonry continued over the planking. A boarded floor with a central trap door moving on hinges so as to admit of access to the shaft, as occasion might require, covered the top. A large gin (Sketch No. 1) filled with the necessary tackling for working the rods and tools, and having a wooden platform supported by massive timber uprights, on which a heavy weight of guns was placed to give the requisite stability, was erected over the shaft. The rods, &c. were originally worked with ropes, but the expenditure of these became so serious as to lead to their being replaced by strong chain cables, which were found in every respect superior. Two chains attached to the ring of a brace-head passed subsequently through a triple block fixed to the apex of the gin, and were then led to two powerful crabs, firmly bolted to large fixed sleepers, at about fifteen or eighteen feet from the gin. A chain was attached to each crab, and on the screw of the upper rod being entered into the brace-head, the crabs were worked simultaneously, and the power of both thus brought to bear in raising the mass of the rods, or in any other necessary manner.

On the 28th of April the actual excavation of the bore was commenced with a six inch auger, being that adapted to the tubing it was intended to employ. On the depth of 120 feet being attained, the quicksand, which had rendered the first attempt abortive, was again met with. The experience of its previous effects had rendered apparent the necessity of securing firmly the joints of the tubes, which was accordingly done by means of four short, but strong screws, in the manner represented in sketch No. II. To this precaution the success of the work so far was undoubtedly to be attributed, as the difficulties were found most serious from the loose, even semi-fluid, consistence of the sand, which on the removal of a portion of the water, then standing in the tubes within 15 feet of the surface, immediately rose to seventeen feet, and though the work was continued night and day, actually rose faster than its removal could be effected, so that at the end of eleven days and nights of incessant toil, it had risen from 124 to 103 feet.

Hence it became evident, that the only mode of overcoming the obstacles presented by the sand, was to force the tubes down till coming in contact with some firm stratum, the sand should be excluded; by unrelaxing perseverance and much labour, frequently with an advance of not more than a few inches in the day, the tubes at length attained a depth of 157 feet. The sand was then perceptibly gained upon, and at 159 feet a stiff clay was reached, and the borer which during the prevalence of the sand was always behind the tubing, now passed it, and in twenty-four hours attained a depth of 175 feet.

The open auger it was found could not be used with effect except in working through clay; a valved instrument, therefore, called the "Mudshell," had hitherto been employed for raising the sand. This tool however here became useless, from some defect in the action of the valve, which failed either to admit or retain the sand, now coarse and gravelly, and in consequence it was found impracticable to penetrate with it beyond 175 feet. One of the augers however being fitted with a valve, and otherwise altered so as to retain the sand, was employed with partial success, but not to an extent sufficient to prevent the sand rising in the tubes, since after working twenty-one days, and the tubing having been forced down to a depth of 177 feet 2 inches, it was found impossible to work the auger lower than 167 feet 10 inches; occasionally a partial advance was made, but it was neither permanent nor certain, from the constant variation of the height of the sand in the tubes.

On entering the stratum of stiff clay, above alluded to, the night-work had ceased, but it was again found necessary to resume it, as the only means of overcoming the existing difficulties. The effect of this was to carry the bore successfully to a depth of 182 feet 8 inches by the 27th of July, when a temporary suspension of the operations took place, from the supply of rods having become exhausted. It may be mentioned, that for some days prior to this date considerable inconvenience had been experienced by the stoppage of the borer, both in its ascent and descent, by some obstacle, the nature of which could not be ascertained. Had it been constant in its position, it might have been anticipated that the tubing had again been dislocated or forced from the perpendicular, but so far from this being the case, the borer occasionally descended and was brought up without the least difficulty; this temporary intermission was followed by the re-appearance of the impediment; again it intermitted, and latterly disappeared altogether.

A further supply of the rods having been obtained from Delhi, the boring was resumed on the 13th October, 1836.* During this interval of suspension, however, it was found that the tubes had sunk by their own weight from 183 to 187 feet, and the bore could now be worked to the depth of 189 feet. By the 10th November following, a depth of 238 feet 5 inches had been attained, the chief difficulty in prosecuting the work arising from the imperfect action of the instrument employed in raising the sand, in consequence of which the whole contents of the shell were frequently removed during its passage to the surface. To the construction of the valves of such instruments, much attention ought therefore to be paid, as on the effective action of these, the progress of the operations is most essentially dependant.

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* The following singular circumstances connected with these Delhi rods, may here be placed upon record, though it has been found impossible to obtain any satisfactory explanation of their origin or cause.

1000 feet of rods, in lengths of 20 feet each, were received from the Court of Directors at one time; 500 feet of these were taken indiscriminately for the Fort Operations, and the remaining 500 feet were forwarded to the Magazine at Delhi. On the occasion of the supply in the Fort becoming exhausted, a portion of those sent to Delhi were called for, and 200 feet were in the first instance received, subsequently followed by the remaining 300. On working the two sets together a remarkable difference was observed between them. Under equal strains the rods obtained from Delhi twisted and bent with the utmost facility, while those employed in the Fort operations continued rigid and straight, so that ultimately the latter alone could be used in the daily work, the others being laid up in store as useless. Had this flexibility been confined to a portion of the Delhi rods, it might have been explicable on the supposition that some flexible rods had been intermixed with the rigid ones, but it was equally observable in the whole 500 feet of them, so that this explanation can scarcely be admitted, especially when it is remembered that in the first instance no sort of selection was employed. The strength of the Delhi was however considerably greater than that of the Fort rods, the former bearing a strain of 19.6 tons on the square inch, without breaking; while the latter yielded to a strain of 16.2 tons per square inch.

On the 15th November, an attempt was made to bring up some water from the bottom of the bore by lowering a bottle with a large brass plummet attached to it, to cause it to sink; but unfortunately before it could be raised, the connecting string broke, and the plummet was left below. Considerable anxiety was excited by this, from the anticipation (subsequently realized) of the auger coming in contact with the plummet, and being jammed within the tubing. On arriving at the depth of 271 feet, the lower part of the mudshell, including the valve, from some unknown cause broke off, and remained at the bottom of the bore. This accident caused much trouble, but after various attempts to extricate the fractured shell, the perforation of an aperture in it, by the use of a jumper, admitted of a strong conical worm auger being screwed into it, and by the hold thus obtained, it was successfully raised to the surface.

At the depth of 324 feet the borer came in contact with the long lost plummet, and became so firmly jammed between it and the tubing as to foil every effort made for its extrication, though the force applied at one time was so great as to raise the whole body of the tubing about 4 inches, the weight of this being certainly not less than 7½ tons, exclusive of friction. To guard against the inconvenience of an accidental fracture of the rods at any considerable distance beneath the surface, while they were subject to such strains, Captain Thomson of the Engineers suggested that the uppermost rod should be made *thinner* and *weaker* than those within the bore (so as to give way first) but yet capable of bearing a strain of 25 tons. The force subsequently applied caused the rods however to break at their connection with the mudshell, and though they were all brought up, the tool remained below. A new operation therefore became necessary for extracting the shell, and first the upper portion of it was considerably widened by the use of a jumper. A drill was then introduced, and after several day's labour a hole, sufficiently large to admit of the conical worm auger being screwed into the shell, was drilled. The entire shell was immediately brought up, bearing ample indications of having been in contact with the plummet, but leaving it still at the bottom of the bore.

On the first of October, 1837, the depth attained by the tubing was 431 feet, while the depth of the bore varied from 418 to 426 feet, according to the height of the sand. The water stood from ten to twelve feet from the surface, according to the seasons. By the 30th of April, 1838, the bore was 460 feet deep, and by the 18th September following, a total depth of 481 feet was reached. Just prior however to that depth being attained, the progress of the tubing was arrested by large stones requiring the use of the jumper. By its aid the tubing was again set free, but at 481 feet again arrested, and a repetition of the employment of the jumper became necessary. As the tool originally employed proved insufficient to fracture the stones then met with, a larger and heavier one was attached to the rods, and after a few blows, seemed to have effected its purpose; but on attempting to raise it again it was found to be so firmly jammed that every attempt at dislodging it proved fruitless. A great power was simultaneously applied to raising the rods, and forcing down the tubes, but with no other effect than the perceptible elongation of the former. About 150 blows of a ram, weighing 2½ cwt., with a fall of fifteen feet, were then given to the head of the rods, in the hope that the vibration thus communicated to them would tend to loosen the jumper from its hold. The large accumulation of sand over the tool and round the rods rendered it however problematical if the vibrations ever reached the jumper; and if they did, there can be little doubt that the above cause tended most materially to diminish their intensity, as no useful result followed the trial of this experiment. Again, and as a final effort, the tubing was securely held down, and four powerful jack-screws were applied to raise the rods, which after stretching two feet six inches, and thereby affording a gleam of hope that the difficulty was vanquished, unfortunately broke off at one of the connecting joints, 160 feet from the surface, the remaining 320 feet attached to the jumper, being left within the bore.

Under these circumstances the only hope of being able to continue the operations lay in the practicability of unscrewing and raising the rods, and this after much difficulty was at length so far satisfactorily effected by the use of an ingenious instrument designed by Captain John Thomson, that 290 of the 320 feet of the rods were successfully extracted. This instrument consisted of three steel arms rivetted to an iron bell, in the manner shewn in sketch No. III, and subsequently welded to the end of the undermost boring rod. The interior surfaces of the steel arms were cut in grooves so inclined, that on the head of the rod to be extracted being grasped within them, and a rotatory motion communicated to the instrument from above, the teeth cut into the soft iron, and by the hold thus obtained, the unscrewing and raising were effected. The bell acted as a guide, and was made of diameter just sufficient to admit of the instrument being readily worked within the tubing. It became necessary to pass iron pins through all the connecting joints of the rods, otherwise the rotatory motion would have unscrewed them.

On the 16th of February, 1839, the instrument above described was again successfully employed in unscrewing twenty feet more of the fractured rods. After this a single rod, only ten feet in length, remained attached to the jumper, and repeated attempts were made to effect its extrication, till at length during one of these, its joint unfortunately broke off, leaving the difficulty greater than ever. The only remedy which presented itself, was to construct a second instrument of which the steel arms would be long enough to lay hold of the shoulder strap in the centre of the rod. This instrument, after several unsuccessful attempts had been made with it to unscrew the broken rod, also gave way, the upper part appearing with one arm attached to it, while the other two arms attached to the bell remained below. By the use of the conical worm auger the broken instrument was occasionally raised as high as thirty feet, but the hold of it could never be retained to any greater height, some obstacle to its further progress upwards invariably meeting it there, and effectually preventing its removal.

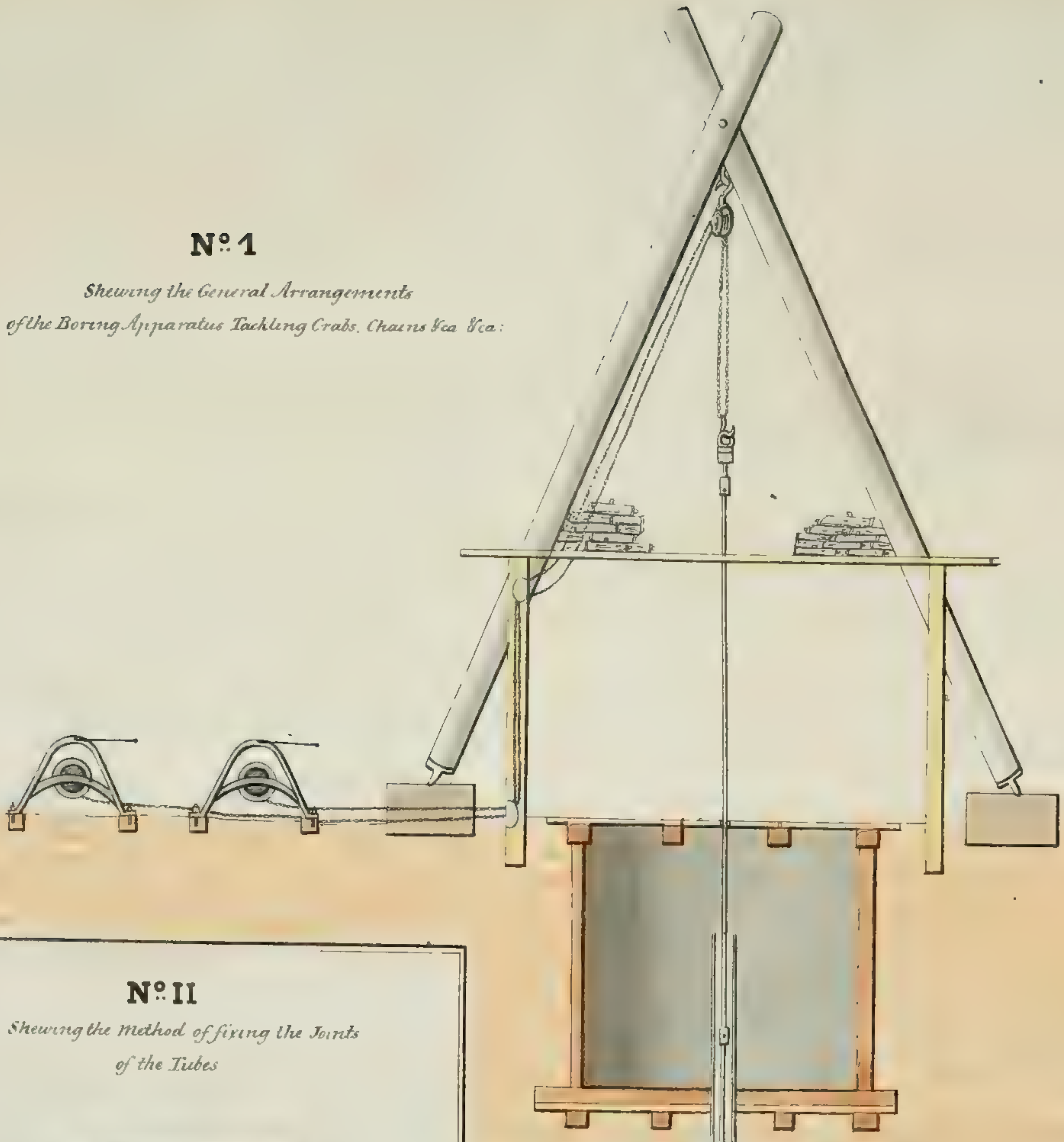
From the 10th to the 15th February, 1840, the work was prosecuted night and day without intermission, as a final effort to remove the sand which had accumulated over the broken instrument, rod, &c. and thus to admit of another tool (designed by Sergeant Longhurst, Sappers and Miners) to be used with greater facility. This tool shewn in sketch No. IV. consisted of an iron rod with four strong palls attached to it, and so constructed, that while the tube was passing down the tubing, or within the bell of the broken instrument, they lay close to the rod, but on its passing completely through, they moved on their axes and caught underneath the tubing or bell, so as to give fulcra for the force from above to act upon. In this instance, however, as before, the attempt terminated in disappointment, for though the broken instrument was occasionally raised a few feet, every exertion failed in raising it to the surface.

A long continuance of unceasing exertion on the part of those employed having thus proved insufficient for the removal of these obstacles, the Committee considered it their duty to discontinue, and were on the eve of communicating to Government their unanimous opinion that a further prosecution of the boring operations would only be incurring expense, for which there was no prospect of any adequate return, when it was suggested to them that some good effect might result from the explosion of a charge of powder, contained in a water-tight case, in the immediate vicinity of the broken tool and jumper. The Committee deeming it possible that the concussion thereby caused might loosen the hold of the jumper, or fracture the broken tool, so as to admit of its fragments being raised to the surface, and willing to adopt any expedient which promised them the power of continuing their labours, determined to make the proposed experiment. There was reason to believe that the steel arms of the lifting tool were considerably expanded and in contact on each side with the tubing, it was therefore desirable that the powder should be lodged within the arms, so that they at least might be broken in pieces by the first explosion. With this view a strong tin case, carefully soldered and terminating in a pointed extremity, was prepared for the reception of about 15 lbs of powder, but preparatory to charging it for explosion it was filled with dry sand, firmly plugged up, covered with water-proof composition, and lowered to the bottom of the bore. On raising it again, the original cylindrical case was found to have been compressed by the water, into the shape of an octagon, acute ridges, about $\frac{1}{4}$ of an inch in height, alternating with the flattened sides (sketch No. V.) The pressure had ruptured the tin at the edge of the top of the case, and the sand was saturated with the water. A double case was then constructed, having interior cross pieces to strengthen it, but a similar result to the preceding followed the lowering of this, and for it also the pressure (upwards of 5,000 ℔s.) was found too great. A cylinder of wrought iron was then prepared, and on sending it down the bore it was found so far capable of resisting the pressure of the water as to retain its shape, but the sand was still damped. Since however the water had only partially wetted the sand, it seemed probable that additional care in soldering and in applying the water-proof covering might exclude it altogether, and accordingly it was determined to make the first attempt with this wrought iron case.

The depth of water being about 465 feet, the galvanic battery was of course the only igniting agent which could be employed; and the following are the details of the arrangements adopted. A wooden plug was turned somewhat larger at one extremity than the collar of the cylinder into which it was subsequently to be driven. On opposite sides of this plug, grooves were prepared for the reception of the interior conducting wires. Considerable difficulty was experienced in making the grooves perfectly impervious to water under great pressure, in consequence of the wires being twisted, but ultimately the following means were employed with entire success. The grooves were first filled with fine Europe sealing wax, and the wires being previously made very hot, were forced into and completely imbedded themselves in it. Subsequently a red-hot iron was held near the wax of each groove, till it boiled freely, and a strip of wood was then forced in over the wire so as effectually to close every aperture. The interior extremities of the wires were as usual connected by a short piece of thin platinum, in contact with which a cartridge of dry fine powder was placed. The main conducting wires were one-sixth of an inch in diameter, and their entire length was nearly 1003 feet. As the bore was lined to the bottom with iron tubing, it appeared essential to insulate the conductors as perfectly as possible, and each wire was accordingly first cased in hempen

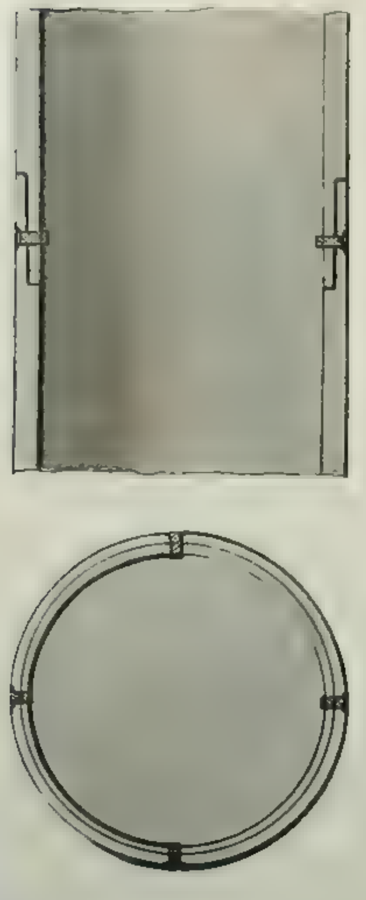
No. 1

Shewing the General Arrangements
of the Boring Apparatus Tackling Crabs, Chains &ca &ca:



No. II

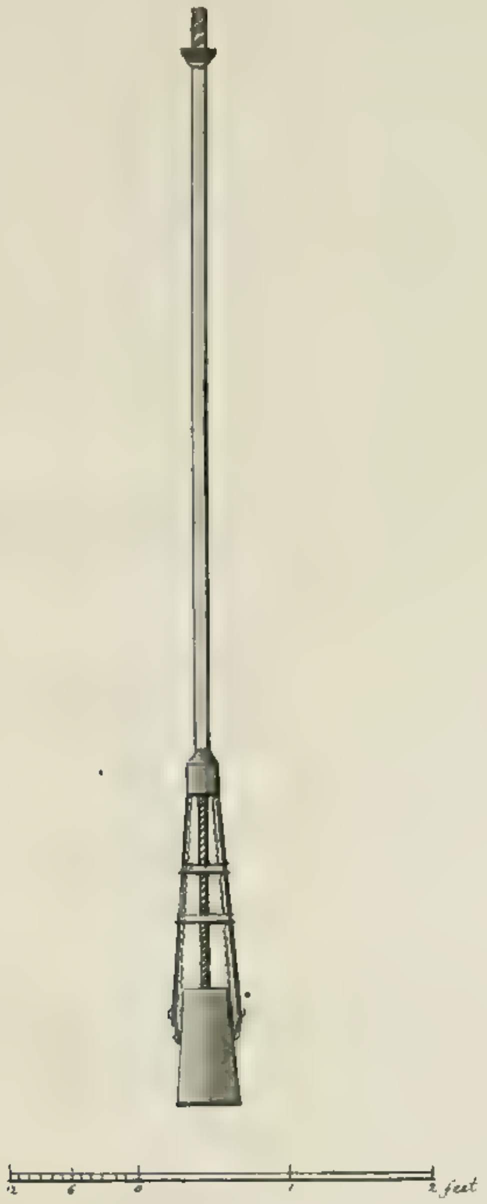
Shewing the method of fixing the Joints
of the Tubes



(Sd) R Baird Smith Lieutt
April 24th 1840

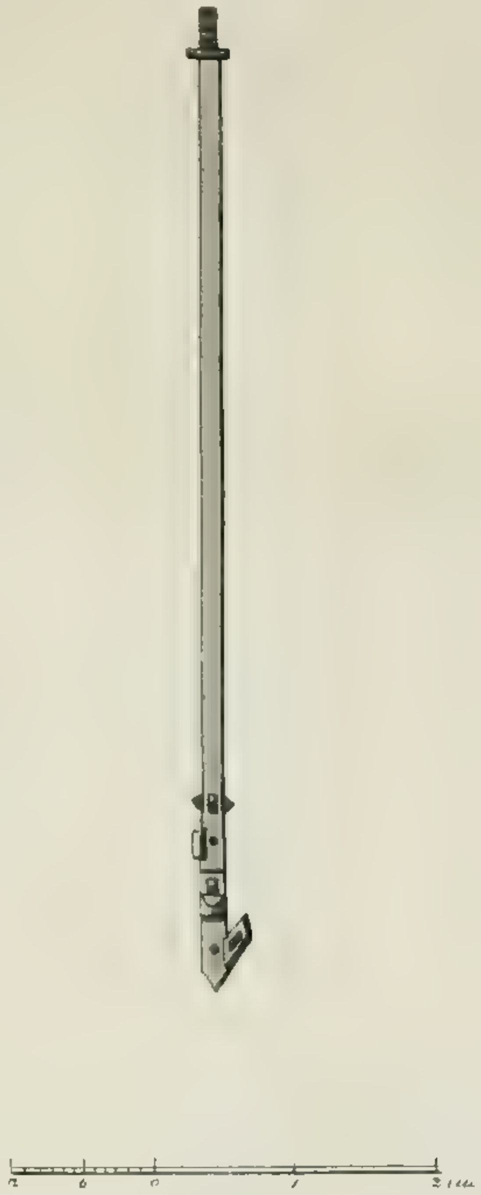
Nº III

Steel-Armed and Toothed Rod Lifting Tool (by Captain Thomson)



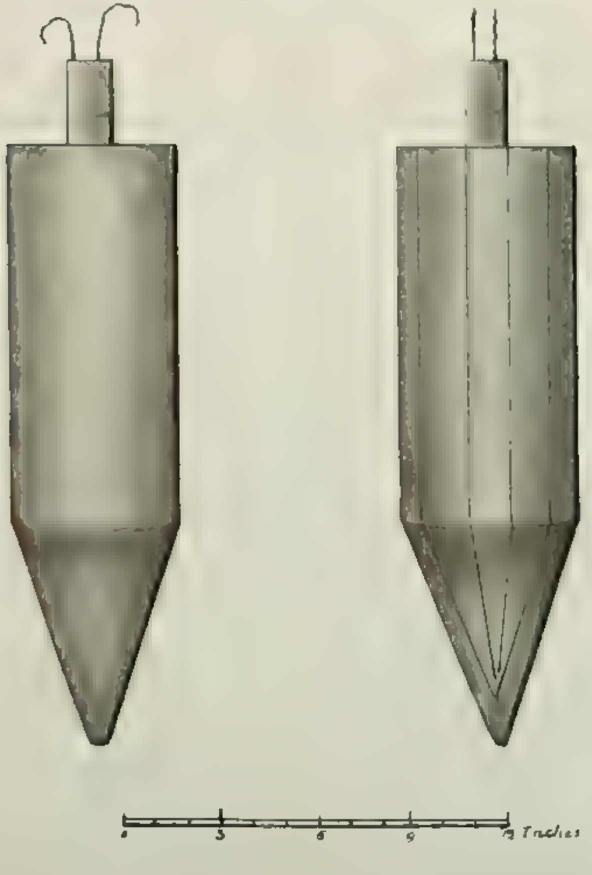
Nº IV

Rod Lifting Tool with moveable Palls (by Sergt. Longhurst



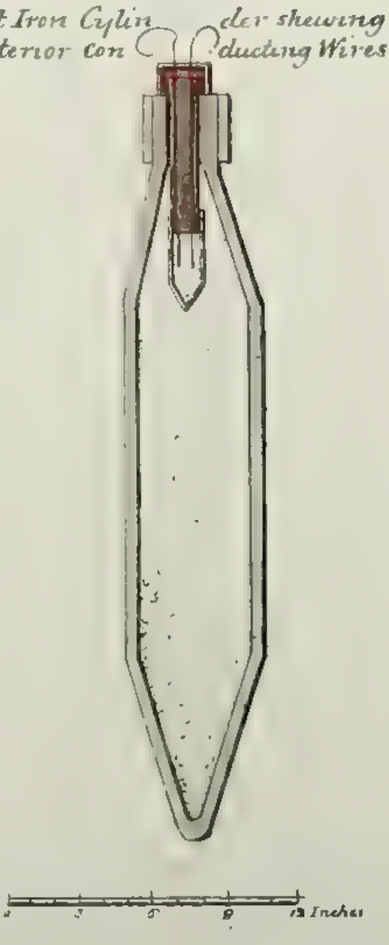
Nº V

Shewing the Cylinder in its Circular and compressed States



Nº VI

Section of the Cast Iron Cylinder shewing the disposition of the Interior conducting Wires &c &c



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5th R Baird [illegible] Lieut
April 20th 1840

strands, over which a thick coating of pitch and grease was applied, and then the two wires were lashed together by similar strands, and again covered with pitch and tallow. A single rope, about an inch in diameter, was thus formed, and on immersing the whole in water, its action was tested, and a battery of twelve indifferent plates sufficed to effect the ignition of powder.

On the charge being placed in the cylinder, and the platinum wire protected by means of a small tin priming tube, the plug was driven into the collar. Over it, and for the purpose of preventing the water forcing its way through the wood, a tin cap, having two holes for the conducting wires to pass through, was carefully driven down and soldered. In order to prevent this cap establishing a metallic communication between the wires, and thus preventing the passage of the galvanic fluid to the platinum wire, the diameter of the apertures for the wires was made considerably larger than that of the wires themselves, and the top of the plug covered with sealing wax. The application of a red hot iron melted the sealing wax, and on the cap being driven down it rose through the apertures and formed an insulating collar round each wire. These arrangements being complete, and the battery of 24 cells, 14 inches × 14 inches, in action, the main conductors were connected to those of the cylinder, and the insulating covering continued over the junction, when the cylinder was lowered to the bottom of the bore. On its reaching this, the circuit was completed, but no explosion followed, and on examination it was found that from the smallness of the priming tube the platinum wire had come in contact with the metal, by which of course its ignition was prevented. It was also found that though the priming powder was dry, the water had reached the main charge, and completely spoiled it. Further precautions being taken, several attempts were made, but all with the same result, and it became evident that the wrought iron case could not be rendered water-tight. Recourse was then had to casting a cylinder of iron half an inch thick throughout, and on trial this was found to be perfectly capable of resisting the pressure of the water, and preserving the charge dry. The first attempt with this failed from some unascertained cause, and as it was thought possible that some portion of the conductor might have come in contact with the iron tubing, an additional covering of lashings, with pitch and grease, was applied for a second attempt.

This also failed, and unfortunately in raising the cylinder, to endeavour to discover the cause of failure, the lifting rope gave way, and it became necessary to haul on the conductor. This had been done once or twice before, without any bad effects, but on this occasion the junction of the wires at the collar of the cylinder was not sufficiently strong to bear the weight, and the case after being raised for some distance dropped back to the bottom of the bore. All hopes of benefit from this expedient being thus summarily disappointed, it only remains to be stated, that the operations of the Committee were finally closed on the 20th of April, 1840.

Throughout the course of the preceding narrative, all reference to the geological information the labours of the Committee have been instrumental in eliciting, has been avoided, from a desire to render the mechanical details as continuous as possible, but as few such opportunities as the present have ever been given for observing the structure of alluvial Deltas, a condensed summary of the various points of interest to the geologist is now appended.

After penetrating through the surface soil to a depth of about ten feet, a stratum of stiff blue clay, fifteen feet in thickness, was met with. Underlaying this was a light coloured sandy clay, which became gradually darker in colour from the admixture of vegetable matter, till it passed into a bed of peat, at a distance of about eighty feet from the surface. Beds of clay and variegated sand, intermixed with kunkur, mica, and small pebbles, alternated to a depth of 120 feet, when the sand became loose, and almost semifluid in its texture. At 152 feet the quicksand became darker in colour and coarser in grain, intermixed with red water-worn nodules of hydrated oxide of iron, resembling to a certain extent the laterite of South India. At 159 feet a stiff clay with yellow veins occurred, altering at 163 feet remarkably in colour and substance, and becoming dark, friable, and apparently containing much vegetable and ferruginous matter. A fine sand succeeded at 170 feet, and this gradually became coarser and mixed with fragments of quartz and felspar to a depth of 180 feet. At 196 feet, clay impregnated with iron was passed through, and at 221 feet, sand recurred, containing fragments of limestone with nodules of kunkur and pieces of quartz and felspar; the same stratum continued to 340 feet, and at 350 feet a fossil bone, conjectured to be the humerus of a dog, was extracted. At 360 feet a piece of supposed tortoise shell was found, and subsequently several pieces of the same substance were obtained. At 372 feet another fossil bone was discovered, but it could not be identified, from its being torn and broken by the borer. At 392 feet a few pieces of fine coal, such as are found in the beds of mountain streams, with some fragments of decayed wood, were picked out of the sand, and at 400 feet a piece of limestone was brought up. From 400 to 481 feet fine sand, like that of a sea-shore intermixed largely with shingle, composed of fragments, of primary rocks, quartz, felspar, mica, slate, limestone, prevailed, and in this stratum the bore has been terminated.

In conclusion, the Committee have much pleasure in acknowledging the valuable aid derived by them on many occasions of difficulty from the advice and ingenuity of Captain J. Thomson of Engineers; and they desire also to express their entire approval of the zeal and intelligence uniformly displayed by Sergeant Thomas Longhurst of Sappers and Miners, during the whole time he was in charge of the details of the boring operations.

D. McLeod *Col. and Presdt.*
A. Irvine, *Major.*
F. P. Strong.
W. R. Fitzgerald.

Fort William,
Chief Engineer's Office,
May 15*th*, 1840.

P.S.—Since the above Report has been signed by the Members, I have recollected a most unintentional omission, for which I am entirely responsible, and which I am therefore desirous of supplying.

It is due to Lieutenant Richard Baird Smith of Engineers, to state that he has not only taken a great interest in all our proceedings, but has rendered great assistance in carrying them on during the most difficult period of the operations, since he has resided in Fort William; moreover, the employment of the Galvanic Battery to blow up the lower portion of the tubing, &c. was suggested to the Committee by him, and the apparatus applied in that process, as above described, was entirely on his design. I may add, that his intelligence and knowledge of the subject, enabled him to give essential aid in arranging the materials for the above Report.

D. McLeod, *Colonel,*
Chief Engineer.